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WEIGHTS OF VARIOUS COALS

BY

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WEIGHTS OF VARIOUS COALS.

By S. B. Flagg.

INTRODUCTION.

Many different kinds of coal have been tested and analyzed by the Bureau of Mines in the course of its investigations relating to the purchase and use of fuel by the Government and to safety in coal mining. Advantage has been taken of the opportunity thus afforded to obtain information as to the differences in weight of the different varieties.

Probably most people know that different coals vary somewhat in weight, but there seems to be little available information as to the range of this variation. Marks [a] gives the specific gravity, or weight compared with an equal volume of water, of anthracite as 1.4 to 1.8; of bituminous coal as 1.2 to 1.5; and of lignite as 1.1 to 1.4. Marks also gives an average value of 97, 84, and 78 pounds for the weight of a solid cubic foot of each of these fuels. These figures are useful in computing the amount of coal in the ground under a given area, but most persons are more interested in the weight of a cubic foot of broken coal as delivered or as stored. Obviously, variations in the weight of the solid coal affect the weight of the coal as delivered, and one must not expect a cubic foot of lignite in a pile to weigh as much as a cubic foot of anthracite. However, factors other than variations in specific gravity affect the weight of a cubic foot of delivered or stored coal. Among these are the quantity of surface moisture, the proportions of coarse and fine coal, and the amount of shaking or settling.

CHANGES IN WEIGHT OR VOLUME BY WETTING AND SHAKING.

The Bureau of Mines has never undertaken to determine how far each one of these factors affects the weight of a cubic foot of coal, but the following table shows the results of some observations of the changes in weight and volume of one type of coal from wetting and from shaking or settling. This sample was a bituminous coal from a mine in Westmoreland County, Pa., which was working both the Upper and Lower Freeport seams.

[a] Marks, L. S., Mechanical engineers' handbook, 4th ed., 1916, p. 455.

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TABLE 1.—*Changes in weight or volume of coal by wetting and shaking.*

	Dec. 13, 1915.	Dec. 13, 1915.	Dec. 16, 1915.	Dec. 16, 1915.	Jan. 20, 1916.	Jan. 21, 1916.	Jan. 22, 1916.	Jan. 24, 1916.	Jan. 25, 1916.
	Nut.	Slack.	Nut.	Slack.[a]					
Weight of 8 cubic feet of coal in original condition (pounds)	351.5	393	363	372	388				
Weight of 8 cubic feet of same coal after wetting (pounds)	364.5	419	370	393	416	392	388	386	388
Settling when shaken (inches)					1	1½	1½	2	1½
Total weight of original 8 cubic feet of coal, moist condition (pounds)	364.5	426	371	408	421	396	391	389	388
Moisture in coal in original condition (per cent)	[b] 1.5	[b] 2.5	1.85	2.13	3.26				
Moisture in wet coal (per cent)	5.0	9.6	3.97	10.76	10.8	5.20	3.99	3.50	3.26
Weight of coal per cubic foot in original condition (pounds)	44	49.1	45.4	46.5	48.5				
Weight of moist coal per cubic foot (pounds)	45.6	52.4	46.3	49.1	52.0	49.0	48.5	48.25	48.5
Increase in weight of unit volume of coal through wetting (per cent) [c]	3.64	6.72	1.98	7.74	7.22	1.03	0	[d] 0.51	0
Volume of original 8 cubic feet of coal in moist condition (cubic feet)	8.00	8.134	8.022	8.306	8.10	8.082	8.062	8.062	8.00
Increase in volume from increase in moisture (per cent)	0	1.67	0.27	3.8	1.24	1.02	0.77	0.78	0
Reduction in volume from shaking (per cent)					4.2	6.25	6.25	8.34	6.25

[a] Determinations of Jan. 20–25, 1916, were made with the same sample of coal. This coal was wet on the 20th, and exposed to the atmosphere.
[b] Moisture assumed.
[c] Volume obtained by shoveling the coal loosely into a box measuring 2 feet by 2 feet by 2 feet and leveling off with a straightedge.
[d] Decrease.

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CONCLUSIONS BASED ON TESTS.

The results presented in Table 1 seem to justify the following conclusions:

1. Of two samples of any coal that are composed of the same proportions of pieces of different sizes, the sample having the higher moisture content will usually weigh the more per cubic foot.

2. The sample of higher moisture content will usually occupy more space for the same number of pounds of (dry) coal than will a sample of lower moisture content. However, the increase in volume for the wet coal is not as great proportionately as is the increase in weight per cubic foot.

3. Coal shoveled loosely into a container will settle appreciably if the container is shaken, and the weight per cubic foot will be correspondingly increased.

4. Slack coal composed of a mixture of the smaller pieces up to and including nut size weighs more than screened nut coal.

This last statement coincides with the conclusions drawn from experiments with concrete mixtures, which have shown that a much denser mixture can be made by using certain proportions of various sized pieces. Pieces of nearly uniform size when piled leave about 45 per cent of voids. If these spaces are filled with finer coal of uniform size the weight of the mass is increased and the interstices in the finer coal can again be filled with still finer pieces, resulting finally in a dense mass. It is evident, therefore, that the relative proportions of fine and coarse material have a considerable influence on the weight per cubic foot of the mass.

WEIGHTS OF 177 SAMPLES.

Most of the coals for which weights per cubic foot were determined were received in barrel shipments for test in small low-pressure boilers; hence domestic rather than steam sizes predominated. Table 2, following, shows the weights per cubic foot determined by shoveling coal loosely into a box measuring 2 feet by 2 feet by 2 feet and leveling off with a straightedge. For some samples two weights are shown, one being the value for the coal as received and the other for coal broken so as to have no lumps larger than a man's fist.

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TABLE 2.—*Weights of various coals.*

Sample No.	Source of coal.				Size.	Weight per cubic foot.	
	State or country.	County or Province.	Place.	Mine or name of coal.		Coal as received.	Broken coal.
						Pounds.	*Pounds.*
1	Alabama...	Bibb.....	Blocton.....	Blocton.....	Domestic.....	45.5	.....
2	.....do.....	Jefferson.....	Pratt City and Ensley.	T. C. I. group..	Run of mine...	54.0	.....
3	.....do.....	Walker.....	Corona.....	Corona.....	75–15–10[a].....	53.0	.....
4	.....do.....	Shelby.....	Acton.....	Acton.....	0–10–90[a].....	53.0	.....
5	.....do.....	Walker.....	Townley.....	Townley.....	.....	51.0	50.5
6	Arkansas...	Johnson (?)....	Clarksville (?)..	Fernwood (?)..	.....	51.5	51.0
7	.....do.....	Franklin.....	Denning.....	Denning No. 2.	Lump.....	53.0	.....
8	.....do.....	Sebastian, Le Flore.	.....	.....	Run of mine...	49.5	.....
9	.....do.....	Franklin.....	Denning.....	Denning No. 2..	.....do.....	59.0	.....
10	Australia...	New South Wales.	Abermain.....	Abermain.....	.....do.....	49.5	.....
11	.....do.....	.....do.....	Cessnock.....	Abedare.....	95–5–0[a].....	43.0	.....
12	.....do.....	.....do.....	West Wallsend.	West Wallsend.	85–10–5[a].....	50.0	.....
13	.....do.....	.....do.....	Newcastle.....	Whitburn.....	Large lumps...	47.0	48.5
14	Canada.....	Vancouver Island, British Columbia.	.....	New East Wellington.	.....	50.0	49.5
15	.....do.....	British Columbia.	Michel.....	Michel.....	Run of mine...	55.5	.....
16	.....do.....	.....do.....	South Wellington.	Wellington.....	Lump.....	52.5	.....
17	China.....	North China...	Kaiping field...	Chao Ko Chwang.	.....	49.5	.....
18	.....do.....	.....do.....	.....do.....	Tongshan and Chao Ko Chwang collieries.	.....	52.5	52.0
19	.....do.....	Southern Manchuria.	Fushun (?).....	Oyama and West.	.....	.....	.....
20	.....do.....	.....do.....	Mukden.....	"Fushun coal"	85–5–10[a].....	47.0	.....
21	.....do.....	Shantung.....	Tsuchuan.....	Tsuchuan, E stratum.	15–5–80[a].....	58.5	.....
22	.....do.....	.....do.....	.....do.....	Tsuchuan, D stratum.	15–10–75[a].....	58.0	.....
23	Colorado....	Las Animas....	Rugby.....	Primrose.....	.....	49.5	.....
24	.....do.....	.....do.....	Aguilar.....	Royal.....	Lump.....	50.5	.....
25	.....do.....	Gunnison.....	Floresta.....	Floresta.....	Pea.....	51.5	.....
26	.....do.....	Garfield.....	South Canyon..	Sunshine Canyon, Wheeler vein.	Lump.....	52.5	.....
27	.....do.....	.....do.....	.....do.....	Sunshine Canyon, D vein.	85–10–5[a].....	49.0	.....
28	.....do.....	Gunnison.....	Crested Butte..	Smith anthracite.	Egg.....	50.0	.....
29	Georgia.....	Walker.....	Pittsburgh.....	Durham.....	60–10–30[a].....	54.0	.....
30	Illinois.....	Williamson....	Herrin.....	Jeffrey.....	.....	49.0	.....
31	.....do.....	St. Clair.....	Belleville.....	Prairie.....	Domestic lump.	49.5	.....
32	.....do.....	Williamson....	Carterville.....	Burr C.....	Run of mine...	55.5	.....
33	.....do.....	Saline.....	Eldorado.....	Eldorado.....	Lump.....	49.5	.....
34	.....do.....	Madison.....	Maryville.....	Donk Bros. No. 2	.....do.....	49.5	.....
35	.....do.....	Perry.....	Du Quoin.....	Majestic No. 6..	Domestic lump.	49.0	.....
36	.....do.....	Williamson....	Johnson City...	Black Briar....	Run of mine...	54.5	.....
37	.....do.....	La Salle.....	Cedar Point....	No. 5.....	80–15–5[a].....	46.0	.....
38	.....do.....	Fulton.....	St. David.....	Big Creek Nos. 2 and 4.	80–15–5[a].....	46.5	.....
39	.....do.....	Williamson....	Marion.....	New Virginia..	Lump.....	48.5	.....
40	.....do.....	.....do.....	.....do.....	.....do.....	No. 2 washed..	46.5	.....
41	.....do.....	Saline.....	Harrisburg.....	O'Gara No. 1...	85–10–5[a].....	46.5	.....
42	.....do.....	Sangamon.....	Andrew.....	Cora.....	75–10–15[a].....	48.0	.....
43	.....do.....	La Salle.....	La Salle.....	No. 1.....	85–10–5[a].....	45.0	.....
44	Indiana.....	Greene.....	Jasonville.....	Calora.....	Lump.....	44.0	.....
45	.....do.....	.....do.....	Linton.....	Black Creek....	70–20–10[a].....	45.0	.....
46	.....do.....	.....do.....	Sullivan.....	Antioch.....	90–7–3[a].....	44.5	.....
47	.....do.....	.....do.....	Jasonville.....	Green Valley...	85–10–5[a].....	48.5	.....
48	.....do.....	Knox.....	Bicknell.....	Tecumseh Nos. 1 and 2.	10–15–75[a].....	47.5	.....
49	.....do.....	.....do.....	.....do.....	Indian Creek...	90–5–5[a].....	49.0	.....
50	.....do.....	Sullivan.....	Shelburn.....	No. 4.....	95–5–0[a].....	48.0	.....
51	.....do.....	Vermilion.....	Clinton.....	Jackson Hill No. 5.	80–15–5[a].....	44.0	.....
52	.....do.....	Vigo.....	West Terre Haute.	Speedwell No. 2.	75–15–10[a].....	44.0	.....

[a] Percentages of lump, nut, and slack.

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TABLE 2.—*Weights of various coals*—Continued.

Sample No.	Source of coal.				Size.	Weight per cubic foot.	
	State or country.	County or province.	Place.	Mine or name of coal.		Coal as received.	Broken coal.
						Pounds.	*Pounds.*
53	Iowa	Appanoose	Centerville	Streepy	60–25–15 [a]	46.5	
54	do	Monroe	Lovilia	No. 7	70–15–15 [a]	47.5	
55	Japan			Meneji		51.5	
56	do			Matsushima	Lump	50.5	
57	do			Hokoku		52.0	
58	do			Meiji		52.0	
59	do			Tadakuma		49.5	
60	do			Kanada		52.0	55.5
61	do			Hojo		51.0	49.0
62	do			Shakano	60–10–30 [a]	55.0	
63	do			Noborikawa	90–10–0 [a]	48.0	
64	Kansas	Leavenworth	Leavenworth	Leavenworth No. 1 and 2.	80–15–5 [a]	50.0	
65	do	do	do	Carr	95–5–0 [a]	55.5	
66	Kentucky	Bell	Cary	Cary and Castro.	98–2–0 [a]	54.5	
67	do	do	Arjay	Glendon	95–5–0 [a]	45.5	
68	do	do	Straight Creek	Barker	95–5–0 [a]	44.0	
69	do	do	Kettle Island	Pioneer	Lump	45.5	
70	do	Knox	Wilton	Wilton	do	47.5	
71	do	Union	Sturgis	No. 2	90–5–5 [a]	49.5	
72	do	Webster	Clay	No. 7	60–20–20 [a]	51.5	
73	do	do	do	do	90–5–5 [a]	46.5	
74	do	Whitley	Red Ash	Grinstead No. 2.	95–3–2 [a]	47.0	
75	do	do	Mountain Ash	Mountain Ash	95–5–0 [a]	43.0	
76	do	do	Williamsburg	Bon Jellico	Lump	45.0	
77	Montana	Carbon	Bear Creek	Bear Creek	90–5–5 [a]	52.0	
78	do	Cascade	Sand Coulee	Lochray	90–5–5 [a]	52.5	
79	New Mexico	McKinley	Gibson	Navajo	80–15–5 [a]	46.5	
80	New Zealand.		Westport	Millerton	10–20–70 [a]	53.0	
81	do		do	Denniston	70–20–10 [a]	52.0	
82	Ohio	Athens	Nelsonville	Stalter No. 1	95–5–0 [a]	49.0	
83	do	Guernsey	Klondyke	Murray Hill No. 2.	85–10–5 [a]	46.0	
84	do	do	Cambridge	Buffalo	60–30–10 [a]	46.5	
85	do	Jefferson	Piney Fork	Piney Fork	70–15–15 [a]	47.5	
86	Oklahoma	Pittsburg	Buck and Carbon.			45.5	
87	do	Okmulgee	Dewar	Dewar	40–20–20 [a]	50.0	
88	do	do	do	do	30–40–30 [a]	50.0	
89	do	do	Henryetta	Henryetta	35–45–20 [a]	48.5	
90	Pennsylvania.			Delaware, Lackawanna & Western anthracite.	Egg	56.0	
91	do			do	Furnace	55.0	
92	do			do	Chestnut	56.5	
93	do			do	Furnace	52.0	
94	do			do	Egg	58.0	
95	do	Schuylkill		do	do	58.0	
96	do	Luzerne		Susquehanna Coal Co. anthracite.	Chestnut	52.5	
97	do			Anthracite	Egg	53.0	
98	do			Delaware & Hudson anthracite.	Pea	54.5	
99	do			Pennsylvania & Reading anthracite.	do	54.0	
100	do			Anthracite	do	53.5	
101	do	Schuylkill		Buck Run anthracite.	No. 1 buckwheat.	50.5	
102	do			Anthracite	Egg	56.5	
103	do	Luzerne	Nanticoke	do	Furnace	54.5	
104	do	Schuylkill		do	Egg	57.5	
105	do			Delaware & Hudson anthracite.	do	57.0	
106	do	Luzerne	Wilkes-Barre	Anthracite	Furnace	54.5	
107	do	do	do	do	Egg	57.5	

[a] Percentages of lump, nut, and slack.

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TABLE 2.—*Weights of various coals*—Continued.

Sample No.	Source of coal.				Size.	Weight per cubic foot.	
	State or country.	County or province.	Place.	Mine or name of coal.		Coal as received.	Broken coal.
						Pounds.	*Pounds.*
108	Pennsylvania.	Luzerne	Beaver Brook.	Hazleton district anthracite.	Egg	56.0	
109	do	Lackawanna	Scranton	Anthracite	Chestnut	52.5	
110	do			Lackawanna district anthracite.	Egg	54.0	
111	do	Allegheny	Epton	Peters Creek No. 2.	Lump	46.5	
112	do	Armstrong	Leechburg	Armstrong	75–20–5 *a*	50.0	
113	do	do	Yatesboro	Yatesboro	90–5–5 *a*	49.5	
114	do	do	Sagamore	Sagamore	70–20–10 *a*	50.5	
115	do	do	Seminole	Seminole	60–25–10 *a*	50.5	
116	do	Cambria	Twin Rocks		5–15–80 *a*	52.5	
117	do	do	South Forks	Argyle No. 1	10–15–75 *a*	51.0	
118	do	do	Expedit	Commercial No. 5.	20–30–50 *a*	52.0	
119	do	do	Saxman	Greenwich No. 3.	10–15–75 *a*	52.0	
120	do	do	Dunlo	Yellow Run	0–10–90 *a*	52.0	
121	do	do	Portage	Plymouth	20–10–70 *a*	51.5	
122	do	do	do	Forge No. 1	15–10–75 *a*	51.5	
123	do	Center	Osceola Mills	Peerless No. 4	45–15–40 *a*	52.5	
124	do	Clarion	Clarion	Cronk No. 5	60–20–20 *a*	49.5	
125	do	do	do	Wilson No. 2	90–5–5 *a*	47.0	
126	do	do	do	Rogers No. 3	95–5–0 *a*	47.0	
127	do	do	do	Owens No. 8	95–5–0 *a*	48.5	
128	do	Clearfield	Hawk Run	Acme	80–15–5 *a*	49.5	
129	do	do	Madera	Leader No. 4	7–3–90 *a*	52.0	
130	do	do	Curwensville	Caldwell	0–10–90 *a*	51.0	
131	do	do	Madera	Madera	30–30–40 *a*	52.0	
132	do	do	Carnwath	Carnwath No. 2.	0–10–90 *a*	49.5	
133	do	do	Dubois	Shaft No. 2	60–20–20 *a*	54.5	
134	do	do	Jefferson Line.	Eriton	70–20–10 *a*	51.0	
135	do	do	Dubois	Dubois No. 1	60–15–25 *a*	53.0	
136	do	Elk		Clarion	40–30–30 *a*	51.5	
137	do	do		Dagus	35–25–40 *a*	50.0	
138	do	Huntingdon	Robertsdale	Robertsdale	60–25–15 *a*	54.0	
139	do	Jefferson	Reynoldsville.	Soldier Run and Trout Run.	65–20–15 *a*	50.5	
140	do	do	Pardus	Pardus	90–5–5 *a*	49.5	
141	do	do	Brockwayville	West Clarion	15–15–70 *a*	52.0	
142	do	Somerset	McDonaldton	Pen Mar Nos. 2 and 3.	0–0–100 *a*	52.0	
143	do	do	do	do	15–10–75 *a*	52.5	
144	do	do	Boswell		10–35–55 *a*	55.0	
145	do	do	Holsopple	Bethel	0–10–90 *a*	53.5	
146	do	do	Ralphton	Ralphton Nos. 1 and 3.	30–10–60 *a*	52.0	
147	do	do	do	Zimmerman Nos. 4 and 5.	0–10–90 *a*	52.0	
148	do	do	Somerset	Quemahoning Creek No. 1.	20–20–60 *a*	53.0	
149	do	Washington		Maple Glen or Peters Creek.	30–35–35 *a*	54.5	
150	do	do	Atlasburg	Atlas	85–10–5 *a*	48.5	
151	do	do	Wyano	Osborne Nos. 1 and 2.	10–40–50 *a*	49.5	
152	Tennessee	Anderson	Briceville	Cross Mountain No. 1.	80–18–2 *a*	46.0	
153	do	Campbell	Westbourne	Jackson	95–5–0 *a*	45.0	
154	do	do	Jellico	Indian Mountain.	80–15–5 *a*	47.0	
155	do	do	Wooldridge	Falls Branch	80–15–5 *a*	45.0	
156	do	do	do	Powhatan	95–3–2 *a*	45.5	
157	do	Claiborne	Bryson	Bryson Mountain.	75–15–10 *a*	47.5	
158	do	Hamilton	Soddy	Soddy	70–20–10 *a*	49.5	
159	do	Marion	Whitwell	Whitwell	90–5–5 *a*	50.0	
160	do	Rhea	Graysville	Graysville	75–10–15 *a*	51.0	
161	Utah	do	Hiawatha	Hiawatha	95–0–5 *a*	44.5	

a Percentages of lump, nut, and slack.

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TABLE 2.—*Weights of various coals*—Continued.

Sample No.	Source of coal.				Size.	Weight per cubic foot.	
	State or country.	County or province.	Place.	Mine or name of coal.		Coal as received.	Broken coal.
						Pounds.	*Pounds.*
162	Washington	Rhea	Black Diamond.		(Briquets)	42.0	
163	do	Kittitas	Roslyn	Nos. 1 and 2	60-30-10 *a*	53.5	
164	do			Burnett and Black Diamond.	(Briquets)	42.0	
165	West Virginia.	McDowell	Davy	Nos. 1-5	94-3-3 *a*	53.0	
166	do	do		Pocahontas 3 and 4 beds.	3-5-92 *a*	57.5	
167	do	Mercer	Freeman	Caswell Creek	20-10-70 *a*	55.0	
168	do	Raleigh	Winding	Winding Gulf briquets.		41.0	
169	do			No. 3 Pocahontas bed.	4-2-94 *a*	54.0	
170	do	McDowell		do	0-5-95 *a*	56.5	
171	do			Pocahontas coal.	5-10-85 *a*	55.5	
172	do			Kanawha region.	75-15-10 *a*	55.5	
173	do			Near Morgantown.	50-20-30 *a*	51.0	
174	Wyoming	Hot Springs	Gebo	Owl Creek		52.5	
175	do	Sheridan	Kooi	Kooi		45.5	
176	do	Sweetwater	Rock Springs.	Blairtown	75-15-10 *a*	50.5	
177	do	do	Superior	"E"	60-30-10 *a*	47.0	

a Percentages of lump, nut, and slack.

CONCLUSIONS.

A study of the foregoing table indicates that heavier weights may be expected for coals of high fixed carbon content than for those of low. Increased ash content seems to lower the unit weight. It is also true, in general, that the coals high in moisture are lighter than those low in moisture and the younger coals are lighter than the older coals.

These variables combine in so many ways, however, that it is difficult to determine from the data available anything more than a general trend, and consequently little use can be made of the knowledge of a change of one or more of the variables.

In using the weights given in this paper the reader must remember that the figures were obtained in a certain way or under certain conditions, and that the weights per cubic foot for the same coals when wet or when stored in a deep pile or bin or in a car that has been jarred and bumped in transit may be quite different. For this reason one should not expect that the use of the weights per cubic foot contained in the foregoing table will give accurate results within say, 10 or 15 per cent, if applied to coal in a storage pile or other place where the material is liable to be in a compact mass.

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